

#### Demonstration of a Large-Scale Tank Assembly Circumferential Friction Stir Welds Via

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## Circumferential FSW



collaboration with the Metallic Materials and Processes Group within ED33 at Marshall This work was accomplished via Special Development Studies 3758 and 3760 funded by the National Aeronautics and Space Administration and was conducted in Space Flight Center.

The tooling modifications and assembly demonstrations were conducted by the LMMSS Huntsville Technical Operations group.

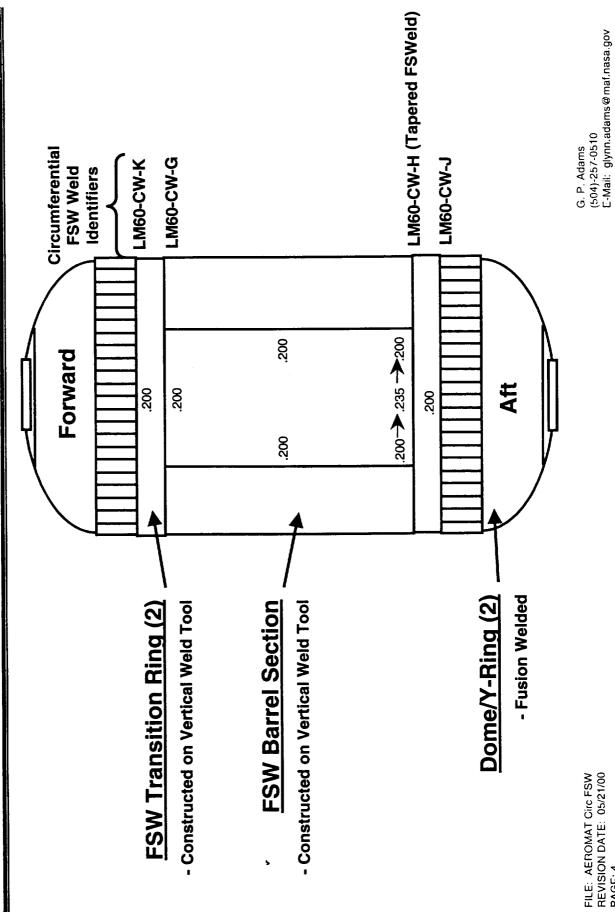
## Circumferential FSW



#### **Objectives**

- Design, fabricate, install and implement modifications to an existing circumferential fusion weld tool (CWT) to conduct circumferential friction stir welds
- Demonstrate the tank assembly process, including both longitudinal CWT and hardware from the Cryogenic Tank Technology Program diameter 2195 tank using the MSFC Vertical Weld Tool (VWT) and and circumferential welds, via assembly of a FSWelded 14-foot

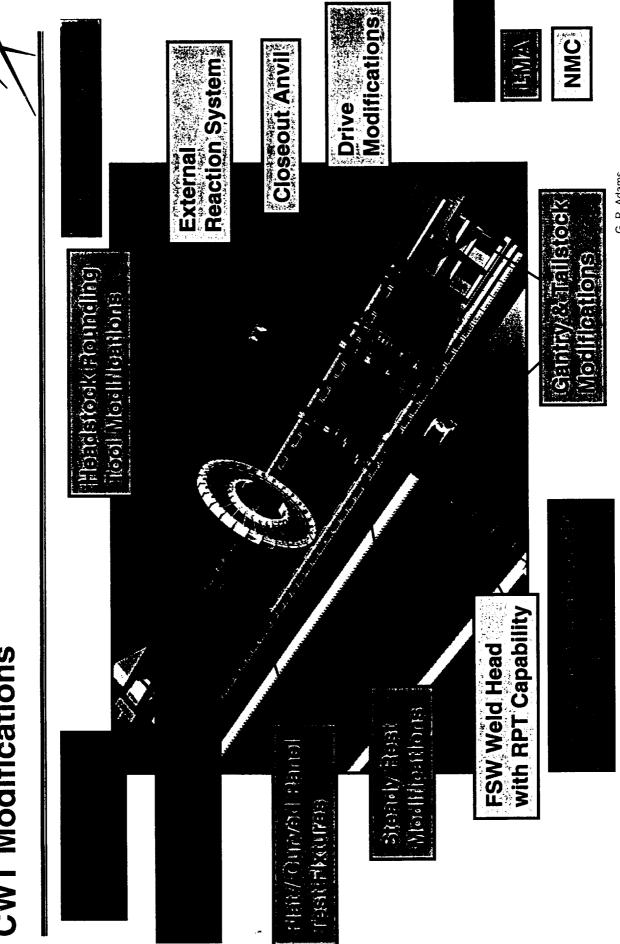
#### **CTTP Hardware**



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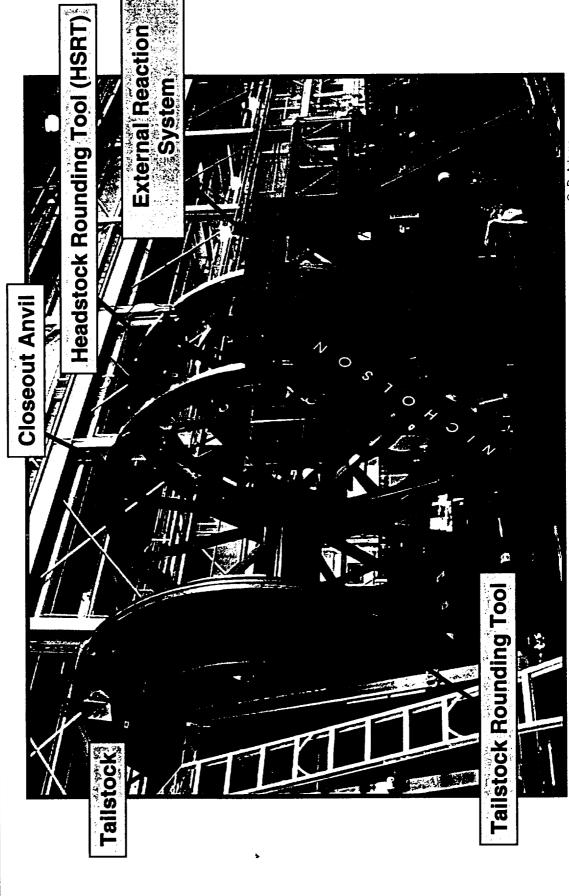
#### **Assembled Tank** G. P. Adams Assembled Ta (504)-257-0510 E-Mail: glynn.adams@maf.nasa.gov **Trim Tool** CWT **|** Overview of Tank Assembly Ring Segment **Brake Forming** Zeppelin Dome Tool -67 65 Rough Machine Final Machining FILE: AEROMAT Circ FSW REVISION DATE: 05/21/00 PAGE: 5

## **CWT Modifications**



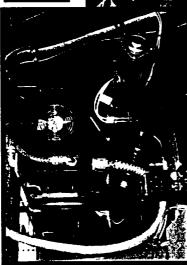
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#### CWT Modifications



#### **CWT Modifications**





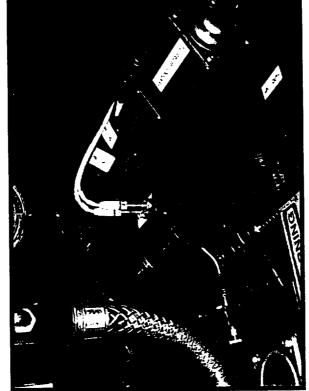
NMC Adjustable Pin Tool Mechanism

- FSW spindle with industry standard tool holder
- 100rpm 1500rpm capacity
- Adjustable pin tool capability
- 12K thrust load capacity
- 4 servo controlled axes (rotation, thrust, pin adjust, cross slide)
  - 2 manually controlled axes (height, lead
- angle)
  2 in- line load transducers (thrust, traverse)
- 1 position transducer (plunge)
- Control system for all provided servo drives

Load path: Pin Tool - Hardware - Anvil - Hardware - External Reaction System

- Closeout anvil
- Attaches to tailstock rounding tool
  - Adjustable diameter
- Individual component max weight 100lbs

# CWT Modifications (Spindle)



**NMC RPT** 

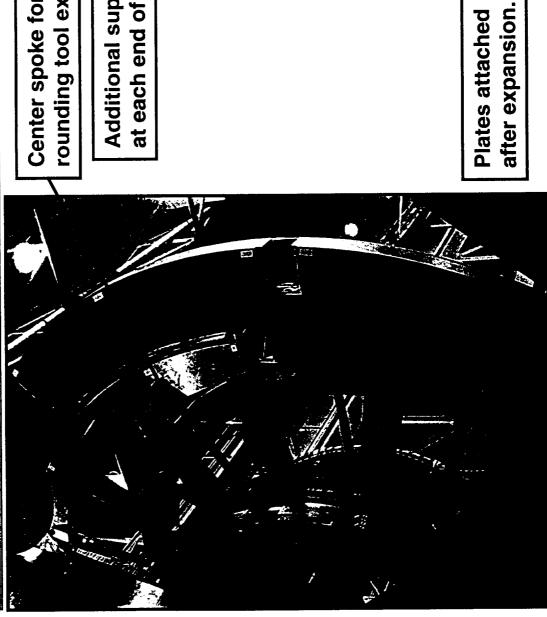


**NMC Spindle** 

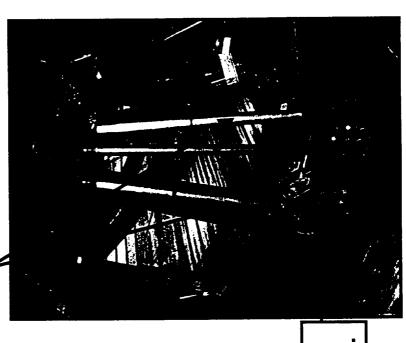
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# CWT Modifications (Headstock Rounding Tool)



Center spoke for actuating rounding tool expansion. Additional support being added at each end of the shoes.



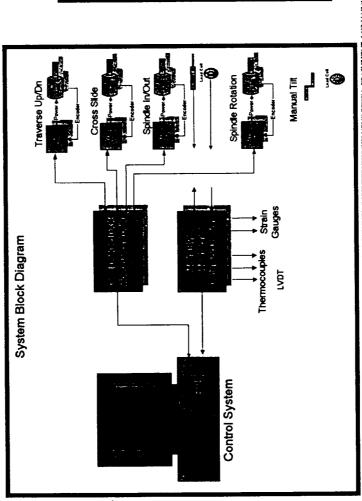
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#### Control System

Control: PC based closed loop controller 4 Servo-motor axes using Galil motion roller PC board

design and integration intended Flexible hardware/software for process development



**Load Cell** 

To controller

To controller

LVDT

Axis

To controller

Encoder

Software: Extensive control algorithms data acquisition and graphic user

> Data Acquisition: 24 channels, 16-bit AD converter, PCI Slot, interfaces with Galil

Plunge Axis: Servomotor driven,

in-line load cell, LVDT

nterface developed using Visual Basic

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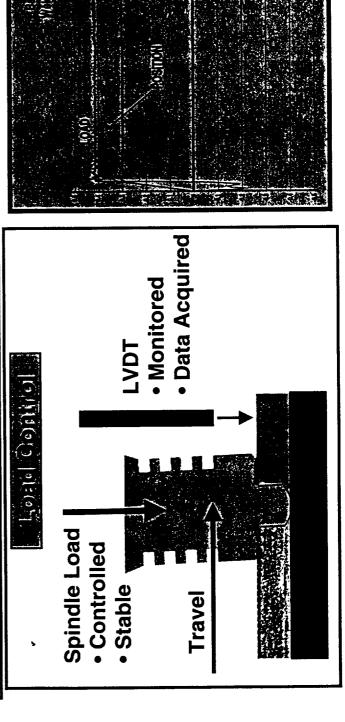
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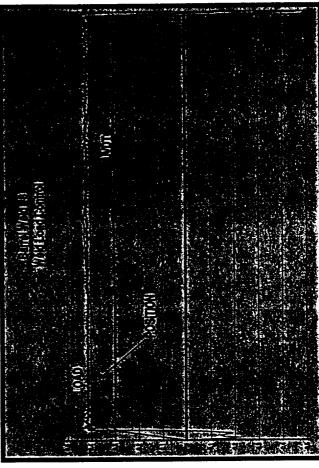
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# **Load Control FSW Process**

- Pin tool depth controlled using plunge servo axis with signal from in-line load cell used as the command variable
- Plunge axis position, as measured by the LVDT, and the servo encoder both monitored for data acquisition
- LVDT measurement serves as fail-safe to ensure that the process is within reasonable bounds

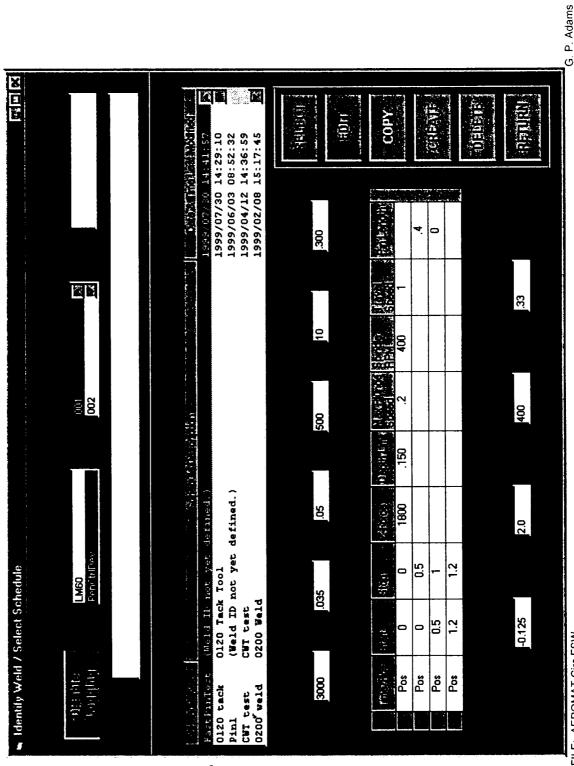




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# Weld Schedule Generation



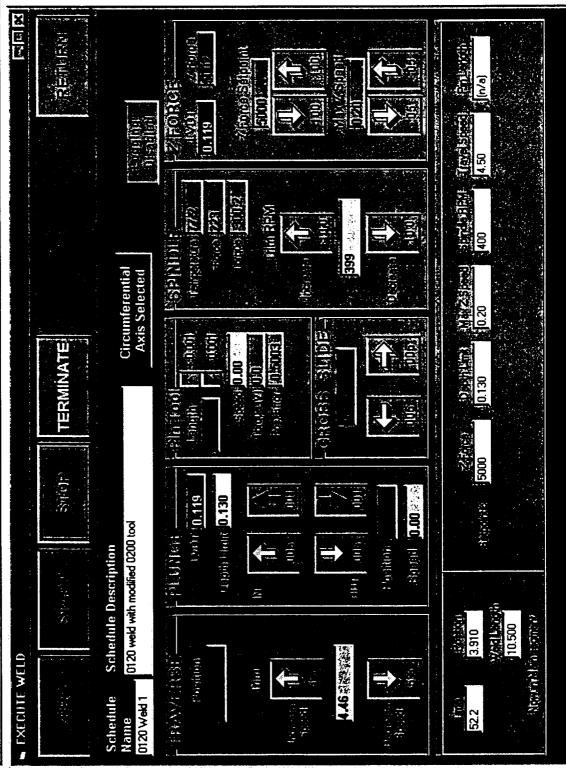
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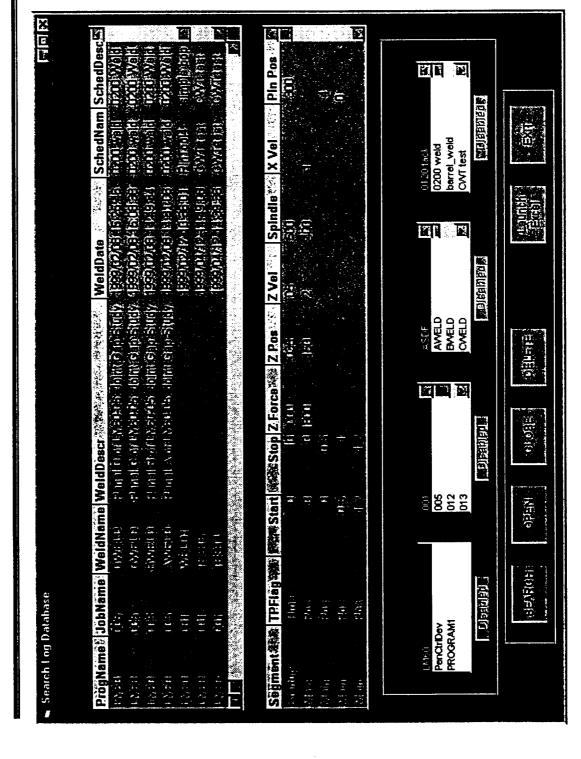
Operator Interface



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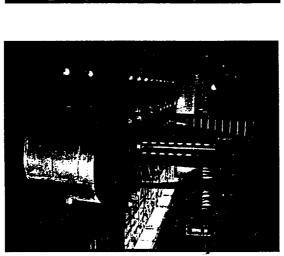


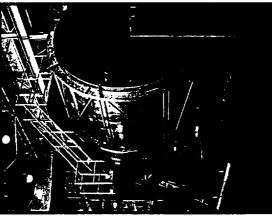


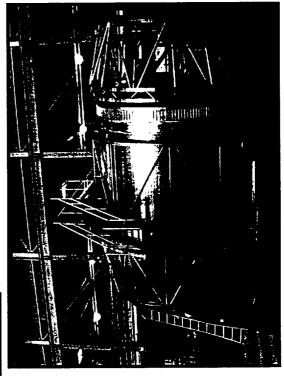
Data Acquisition

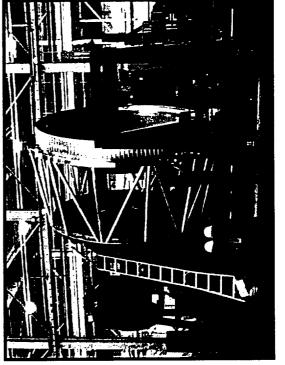


## **Tank Assembly Photos**









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#### Summary



Tapered circumferential welds were successfully demonstrated

The use of a closeout anvil was successfully demonstrated during one of the pathfinder welds

Considerable difficulty maintaining joint fit-up during the weld process

Anvil deflections

Hardware dimensional tolerances

Inadequate clamping

Variations in the heat sink characteristics of the circumferential anvil as compared to the test panel anvil